Natural gamma ray spectrometry for Yata active fault area

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ABSTRACT

Yata fault is one of the active faults in Kinki district, southwest Japan. Its length is 7km north-south course, the fault credibility is categorized as a "Class 1" fault of 5 phase of evaluation, because the Quaternary sediments distribution are shifted by the fault and the fault cliff is recognized clearly. But the fault activity is medium class and the past active time is not clear. For estimating the fault condition near the ground surface, the natural gamma ray survey using a multichannel analyzer with NaI scintillation detector was carried out over the Yata fault area. Natural gamma ray spectral data were corrected by field survey, the measurement time was 3000 seconds per one site, and the spectral data at 44 sites were provided. The data of the fluctuation of natural radioactive nuclides 40K, 214Bi and 208Tl were measured by the gamma ray spectral data, and 214Bi/40K, 214Bi/208Tl fluctuation ratio was mapped on the study area. The results of the mapping, the fluctuation ratios of southeast area were higher than another area, which boundary has discontinuity on the fault line. These patterns of fluctuation ratio 214Bi/40K and 214Bi/208Tl are due to weathering situation of the host rocks. The southeast block may have been moved recently

1. INTRODUCTION

In study of fault and mine, natural gamma ray survey is often used. The natural sources of gamma ray are ^{40}K, ^{218}B and ^{208}Tl. ^{40}K decay to ^{40}Ar by electron capture with emission gamma ray. ^{222}Rn and ^{220}Ra which are daughter elements produce in the process that the radioisotope ^{238}U and ^{232}Th gives rise to a decay series that terminates in stable element. ^{222}Rn and ^{220}Rn decay for a few days and become ^{214}Bi and ^{208}Tl. Because the content of K, U and Th are different by a geological feature, the content of ^{40}K, ^{218}Bi and ^{208}Tl are different by an area. By this, gamma-ray intensity fluctuates by a place. In addition, the gamma-ray intensity changes by a style and degree of weathering, existence of a crack of bedrock. In this way distribution of natural gamma ray intensity reflects the subsurface geological feature state, and this survey is an only method to tell us about its condition as easy. It seems in particular that this method is effective for study of a change of subsurface geological state by fault activity. The natural gamma ray survey was carried out to evaluate a surface geological feature state of bedrock of Yata fault area in northwest of Nara prefecture, southwest Japan.

2. STUDY AREA

The site of a study area is shown in Figure 1. There are many active faults in southwest Japan and is concentrated in Kinki region in particular. Yata fault is one of the active faults in the Kinki active fault system. Yata fault has about 7km length in north and south direction. And it has a fault scarp clearly, which is the reverse fault that the Eastern bloc up-lifted about 50m (Japan Active Fault Study Group, 1991). Geology around Yata fault consists Alluvium, terrace deposits of Diluvium, Osaka group of Plio-Pliestcene, andesite of the Miocene, granite of the late Cretaceous, Ikoma gabbros, gneiss, and Ryoke metamorphic rocks (figure 2).

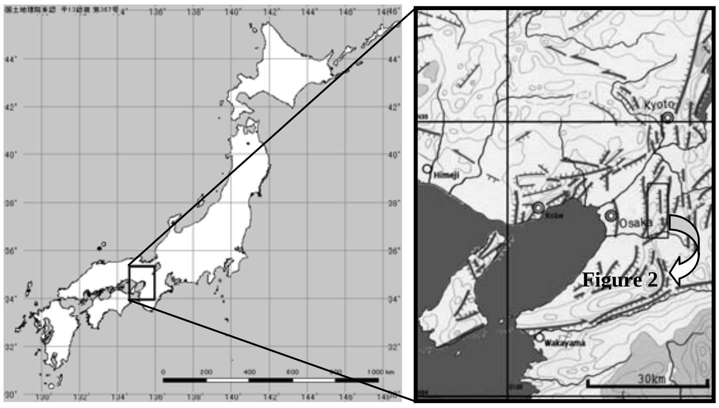


Figure 1: Location map of study area

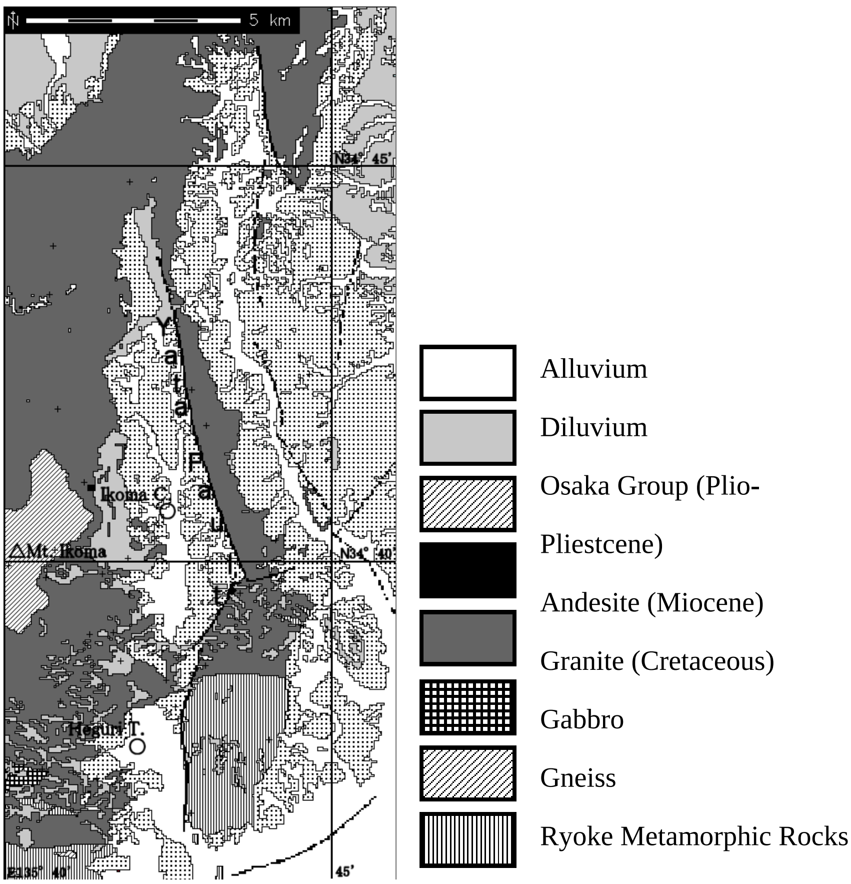


Figure 2: Surface geology map of study area

3. NATURAL GAMMA-RAY SURVEY METHOD

The multichannel gamma-ray spectrometer with 3" NaI (Tl) crystal detector, which was made by Target Inc. was used the measurement. This instrument consists of detector, a Photo Multiplier Tube (PMT) and Multi Channel Spectroanalizer (MCA). It is connected to a laptop PC (Windows XP) by USB connector and collects gamma ray spectrum data with installed detector / MCA control software (Figure 3). A power supply of these instruments uses portable battery. The electric power consumed by PMT and MCA are supplied through USB of a PC. The sensor was put on an outcrop directly and collected the data of natural gamma-ray spectrum. Because potassium was included in plants, spectrum data collection went for the winter season when activity of a plant was small. And a plant piece of a measurement position was removed it and installed survey machine. The applied voltage of PMT assumed 500V at the all sites. To get an enough spectrum counts of each channel, measurement time was set 3000 seconds. In addition, to calibrate the fluctuation of spectrum position to a channel of MCA, spectrum gain was adjusted using ^{137}Cs peak spectrum (662MeV). The gamma ray detector, which was used in this study, was calibrated to gamma ray standard sources (^{60}Co and ^{137}Cs) and other detector with Ge(Li) semiconductor, which has been already calibrated. The location coordinates of a survey site was acquired with GPS at the same time (Figure 4)

Figure 3: Instrumentation for natural gamma-ray survey

Figure 4: Photograph of field data collection

4. ANALYSIS OF THE GAMMA-RAY SPECTRUM AND MAPPING WAY OF THE GAMMA-RAY INTENSITY

Figure 5 shows an example of acquired gamma ray spectrum on the data analyze program. The graph form of a gamma ray spectrum which a natural isotope discharges spreads. However, the peak spectrum of ^{40}K, ^{214}Bi, and ^{208}Tl like Figure 5 are recognized distinctively. The gamma ray dose, which was discharged from each isotope, was evaluated the total counts in each channel within the full width pf a photopeak at half the maximum amplitude (FWHM). Because the instrument measure gamma ray from all directions, the detector has to get rid of a geometric effect of an outcrop. On this account local gamma-ray dose of radioactivity evaluation uses ^{214}Bi/^{40}K and ^{214}Bi/^{208}Tl fluctuation ratio. With a result of this calculation, two gamma ray fluctuation ratio distribution map of the area was drawn using GRASS-GIS. A value of the fluctuation ratio every measurement site where is distributed over at random was converted into grid data with weighted average method, and the result was expressed in contour maps.

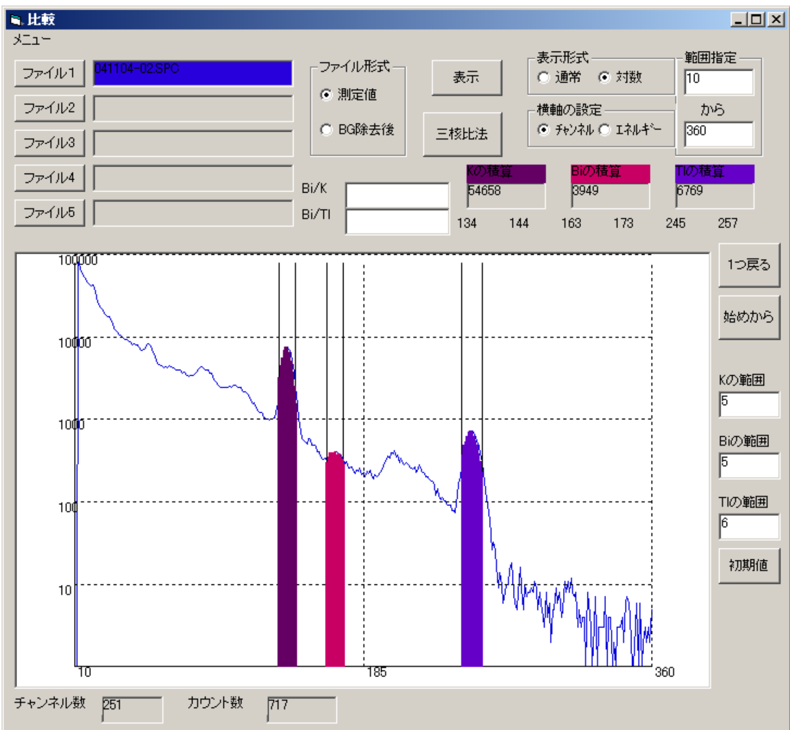
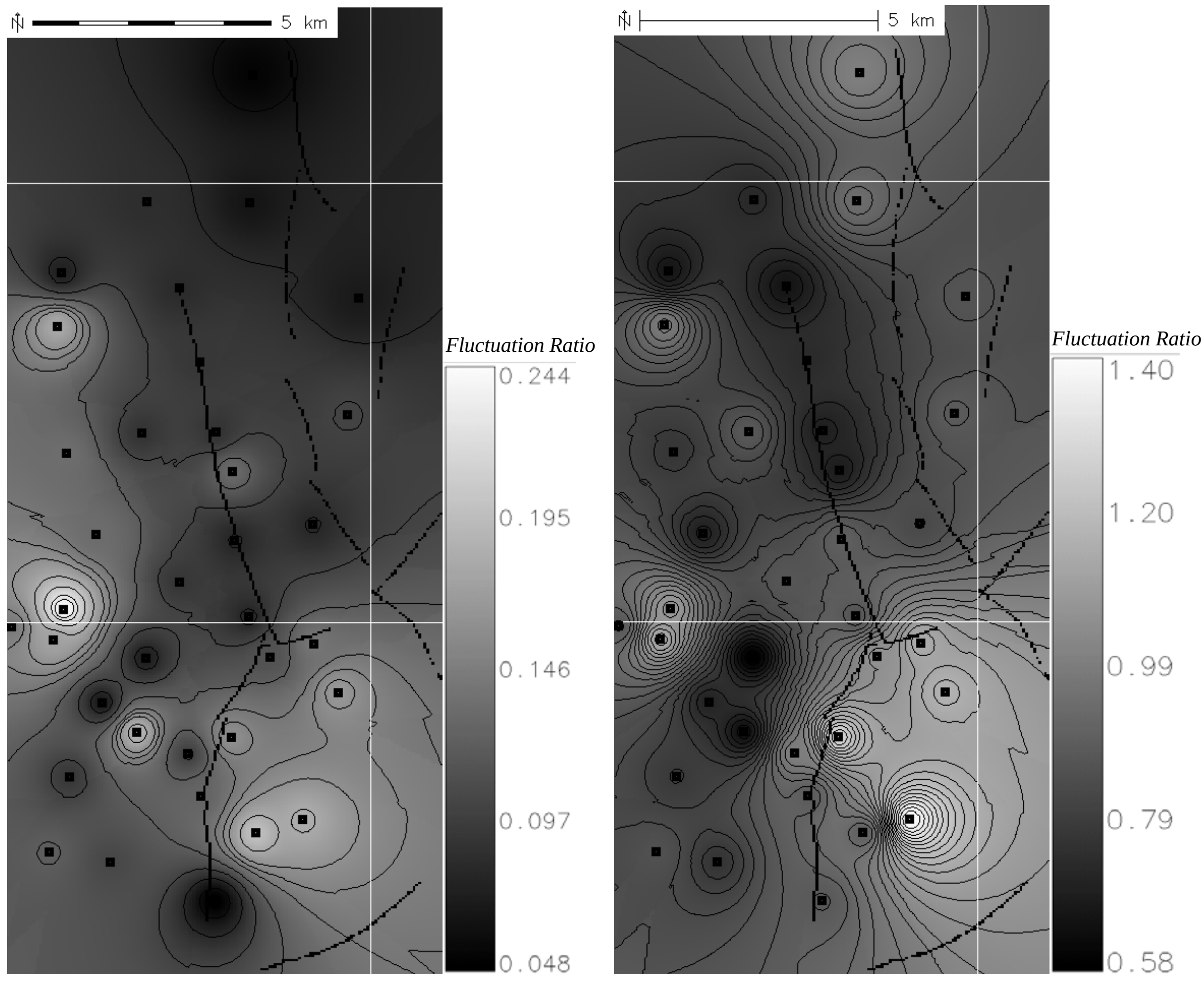


Figure 5: Gamma-ray spectrum histogram on the data analysis program

5. RESULTS AND DISCUSSION

Figure 6 is a contour map of ^{214}Bi/^{40}K and ^{214}Bi/^{208}Tl fluctuation ratio by above method. A contour map (Figure 6a) of ^{214}Bi/^{40}K shows existence of a high ratio part in Ikoma Mountains and Yata fault southeast side of the eastern part. Also a result of ^{214}Bi/^{208}Tl (figure 6,b) shows existence of the high fluctuation ratio part in same area. As a result of both, high fluctuation ratio area is shown with the distribution that is surrounded by a fault line in the southeast part. Generally potassium is susceptible to eluviations and collection by weathering easily. Therefore, the ratio of $^{214}Bi/^{40}K$ reflects chemical composition and weathering of an original rock. Gabbro is distributed over Ikoma Mountains. Originally gabbro has less potassium content relatively. Sedimentary beds and granite and metamorphic rocks are distributed over most of these areas. Therefore, the fluctuation ratio of $^{214}Bi/^{40}K$ was shown greatly in Mt. Ikoma. This can be explained based on eluviations of K from the rocks at the high ratio area of $^{214}Bi/^{40}K$ in southeast part (figure 6a). On the other hand, a collection of K can happen into clay generated by granite weathering at north area. Because of limited mobility of a heavy element such as U and Th. Therefore, the ratio of content of the daughter element Bi and Tl reflect chemical composition of original rocks. However, in Figure 6b, the $^{214}Bi/^{208}Tl$ fluctuation ratio was shown the tendency smaller than southeast part, in the same granite body. In decay series of U, Bi occurs by decay of Rn, but Rn is gas, and Rn is able to move through the cracks in bedrock. And some of Rn may arrive at the surface of the ground. Many cracks exist at bedrock in the Southeast part of study area, and eluviations of K and movement of Rn may occur. These consideration results accord with outcrop observation in the field. Therefore, the southeast segment of the Yata fault was active recently than a north segment. And it is concluded that the southeast block has become an erosion domain now.



a: $^{214}Bi/^{40}K$ b: $^{214}Bi/^{208}Tl$

Figure 6: The contour maps of the fluctuation ratio $^{214}Bi/^{40}K$ (a) and $^{214}Bi/^{208}Tl$ (b)

6. CONCLUSIONS

Natural gamma-ray survey was carried out in Yata fault outskirts area of Northeast Nara prefecture. As a result, an area of the high gamma ray fluctuation ratios was recognized in the Southeast part. The observations indicate the progress and a style of weathering are different in north and south segments of fault. Based upon these results, it was reasoned that the southern part of Yata fault has acted recently than the northern part.

7. REFERENCE

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